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AN INTERAGENCY COMPARISON OF THE FIELD AND LABORATORY PROCEDURES FOR DETERMINING SUSPENDED SEDIMENT

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SEDIMENT SURVEY SECTION

90-06378/

An Interagency Comparison of the Field and Laboratory Procedures for Determining Suspended Sediment *

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December, 1989

* First printed in Ecological Report Series (#89-4) Northern Flood Agreement Manitoba

Abstract

A controlled field study was undertaken to determine whether the suspended-sediment data collected by four agencies working along the Churchill River Diversion in Northern Manitoba are comparable. The results show that a negative bias (≈12%) in concentration is introduced when collecting a dip as opposed to a depth-integrated sample in a wash load dominated river. Further errors (10-30%) are introduced as a result of sample splitting, which is commonly done by the federal and provincial water quality agencies. The implications of these findings to future NFA work are discussed. Recommendation as to future sampling strategies and methods to be used in northern Manitoba are also put forth.

Résumé

Une étude témoin a été effectuée sur le terrain afin de déterminer si les données sur les sédiments en suspension recueillies par quatre organismes le long de la dérivation du fleuve Churchill, dans le nord du Manitoba, sont comparables. Les résultats montrent que, dans un cours d'eau caractérisé par la prédominance de la charge de ruissellement, la concentration présente un écart négatif (≈12 %) lorsque l'on prélève un échantillon en surface par opposition à un échantillon intégré sur la profondeur. D'autres erreurs (10-30 %) sont également introduites lors de la subdivision des échantillons, une pratique courante chez les organismes fédéraux et provinciaux oeuvrant dans le domaine de la qualité de l'eau. Les répercussions que ces résultats pourraient avoir sur les futures activités dans le cadre de l'accord relatif aux crues dans le Nord sont examinées. On recommande aussi l'adoption de méthodes et de stratégies d'échantillonnage pour le nord du Manitoba.

Acknowledgments

The authors are extremely grateful for the assistance provided by: G. McCullough (Freshwater Institute); P. Seidl (Water Quality Branch); D. Williamson (Manitoba Environment); and R. Yungwirth (Water Resources Branch) in analyzing these data in their respective laboratories. Special thanks are due to W. Antonyshyn, D. Bouvier, A. Chomica and J. Millman of the Water Resources Branch for their role in carrying out the field sampling portion of the program.

We are also very thankful for the many comments received from the following reviewers: V. Chacko, Dr. L. Churchland, R. Hale, G. McCullough, L. McKerness, Dr. E. Ongley, F. Penner, P. Seidl, D. Williamson and J.G. Zakrevsky.

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1. INTRODUCTION

1.1 Background

A total of four agencies are involved under the Northern Flood Agreement (NFA) in collecting suspended-sediment data as part of their environmental impact assessment activities along the Churchill River Diversion. The four agencies are:

1) Water Resources Branch (Environment Canada);
2) Freshwater Institute (Fisheries and Oceans Canada);
3) Water Quality Branch (Environment Canada); and
4) Manitoba Environment.

Each of these agencies is involved in on-going data collection programs in the NFA area. However, each agency collects these data using different samplers and different sampling strategies, and analyzes the data using different laboratory procedures.

In 1988, a study was completed by Northwest Hydraulic Consultants Ltd. (NHCL) which assessed the state of knowledge with regard to sediment conditions and effects along the Churchill River diversion route. An important finding noted by NHCL was the need for close coordination between all agencies involved in sediment studies (in the NFA area) to achieve comparability of data. Without comparable data, information synthesis, in any credible fashion, is impossible. In addition to the lack of information on data comparability, little was known about the accuracy and precision of the data collected by the various agencies, thereby limiting their usage.

Therefore, to address these concerns, the NFA Sediment Ad Hoc Committee comprised of representatives from the above agencies was established. During the Committee's first meeting it became apparent that these concerns about data compatibility could not be addressed without further field work. It was therefore agreed that a controlled field study be implemented which would provide some definitive answers. A compilation report documenting available sediment data was also initiated (McKerness, 1989). Both of these initiatives were considered essential for developing a proper sediment budget for the CRD.

1.2 Study Objectives

The main objectives of this study are to determine:

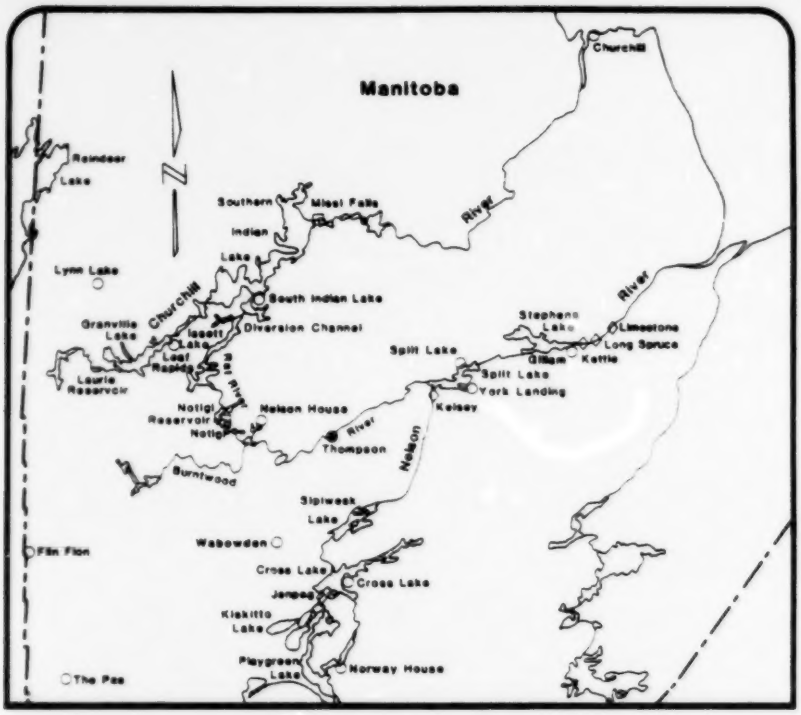
1) The repeatability (precision) of the US D-74 (WRB) and the sampling iron (WQB) samplers under northern field conditions;

2) If there is a correlation between a single vertical depth-integrated sample using a US D-74 and a surface (dip) sample using a sampling iron; and,

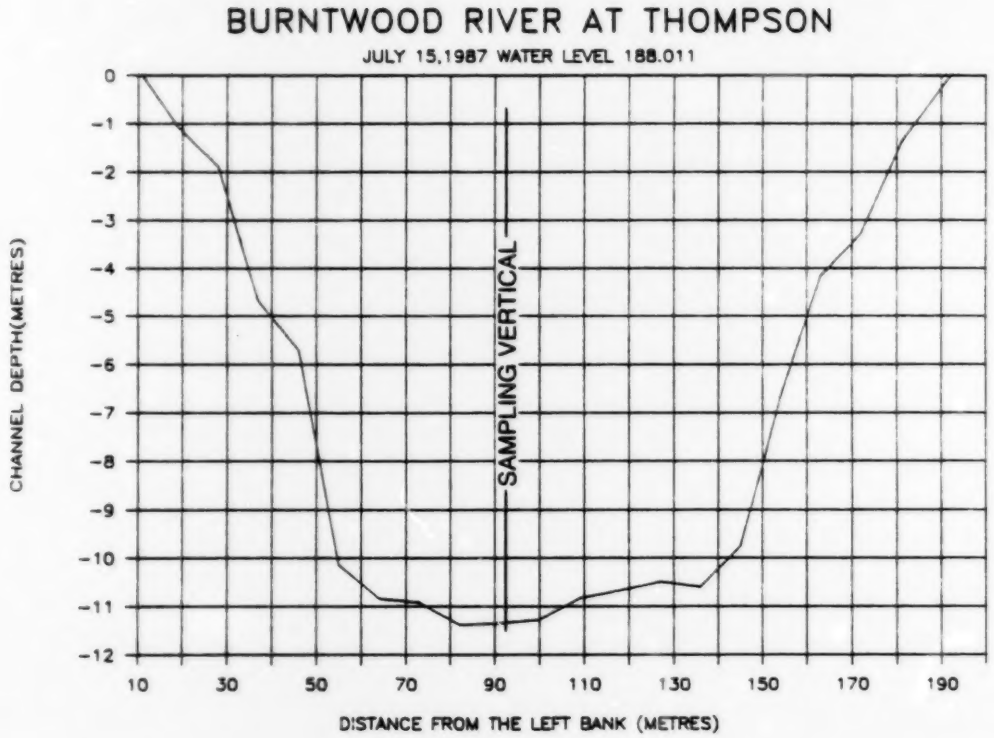
3) Whether the procedures used in the individual organization's laboratories produce comparable results.

1.3 Experimental Design

The Burntwood River near Thompson (Figure 1a) was selected as the most suitable site for this intercomparison study because of its accessibility and the fact that three of the four agencies use this same sampling locale. There is no site which is common to all four agencies.



1a. Site Location

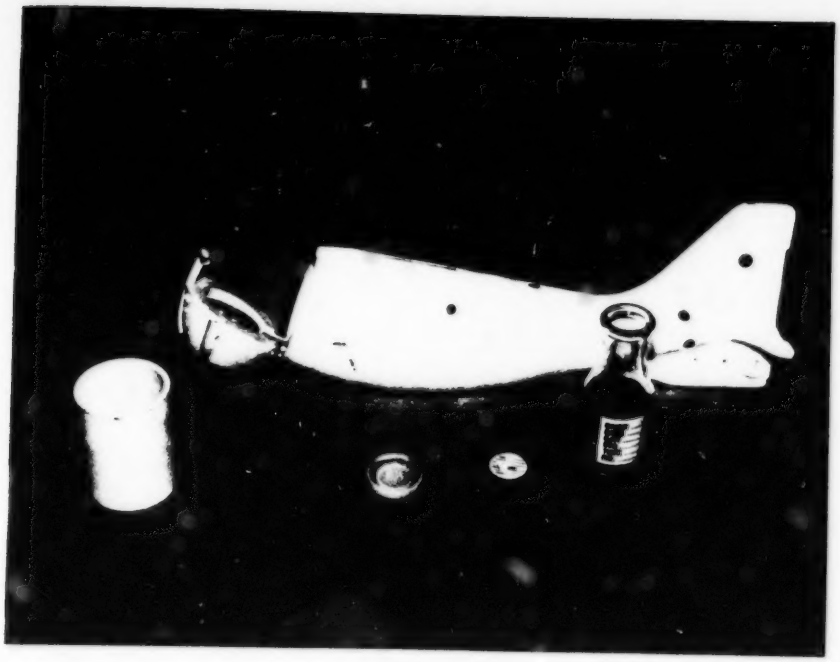


1b. Burntwood River at Thompson Cross Section

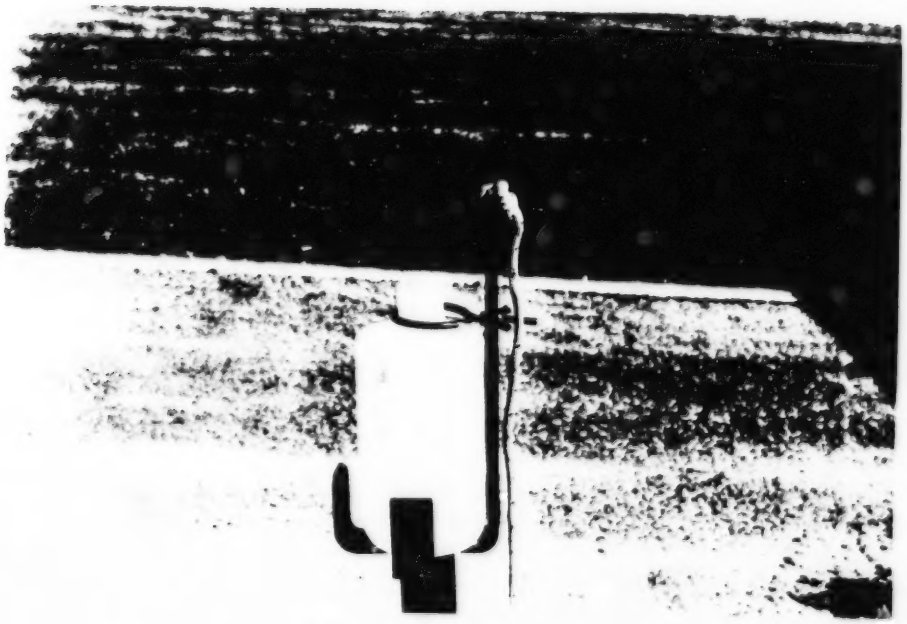
Over the years WRB has collected a considerable amount of data (≈ 400 suspended-sediment samples) at the cross section in Thompson (Figure 1b). Based on information from these numerous measurements, one vertical (V 92 m) was found to be fairly representative of the average concentration in the cross section. This vertical was therefore chosen for the comparison of the dip and depth-integrating methodology.

At this particular site, WRB uses a US D-74 sampler for collecting depth-integrating samples (Figure 2a). The sampler, however, has been modified with a foot valve which triggers a closure upon impact with the bed. This modification was made because the US D-74 is only capable of integrating (return trip) to a depth of 5.8 m (Cashman, 1988). The foot valve thus enables the sampler to integrate one way to a depth of 11.6 m. This approximates the maximum depth which is encountered at this site. For this study, the 3.18 mm nozzle was used along with pint-sized (400 mL) bottles.

The sampling iron is used by numerous water quality agencies for collecting what is referred to as a dip sample (Figure 2b). The sampling iron is allowed to free fall in the water and then retrieved prior to the bottle overfilling (Environment Canada, 1983). A 1-litre bottle was used in this particular study. During this study it was observed that this method resulted in a sample being collected which integrated the upper couple metres of water. Therefore, this method does not provide strictly a dip, as the term implies, but rather a partially depth-integrated sample. Furthermore, it should be noted that unlike the US series of samplers, there is little control over what portion of the water column is sampled.



2a. Depth-integrating, Suspended-Sediment Sampler (US D-74)



2b. Sampling Iron

The sampling program was designed to ensure that a statistically significant number of samples per set (n = 30) would be collected. This would permit a meaningful analysis to be carried out on the precision of these two samplers, and to adequately assess the compatibility of the results produced by different agencies' laboratories. Sampling control (i.e. positioning) and quality assurance (i.e. distilled water blanks) were also taken into account in designing this study (see Appendix A for original study proposal).

The sampling sequence was carried out as follows: first, a depth-integrated sample (sample A) was collected with the US D-74, then four dips with the sampling iron, and then another depth-integrated sample (sample B). This procedure was then repeated until 30 such sets of data were obtained.

The depth-integrating samples (both A and B) were sent along with a set of 30 dip samples to the WRB laboratory for analysis of concentration. The other agencies also each received 30 dips for analysis. For consistency, each agency received the same dip (i.e. first, second, etc.) collected within each set of four dips (see Table B.1 in Appendix B)

Five samples each were collected at the beginning, middle and end of the sampling day with both the sampling iron and the US D-74 sampler. This was done to provide information on the particle size in suspension and to assess whether any sampling biases are directly related to particle size. The 15 samples collected by each of the samplers were composited to obtain a particle-size distribution. The analysis was done at the WRB

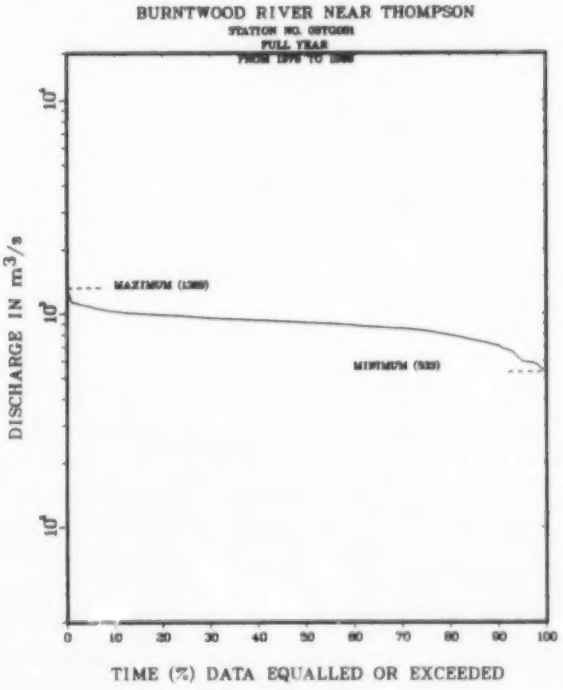
laboratory using the bottom-withdrawal method. This method requires a minimum of 0.15 g of material (Environment Canada, 1987). Unfortunately, the low concentration (≈ 25 mg/L) and the small volume resulted in there being insufficient material (0.13 g) for particle size from the US D-74 composite. A particle-size distribution was however obtained from the sampling iron composite, as twice the volume of water was collected with the litre bottles.

1.4 Site Conditions

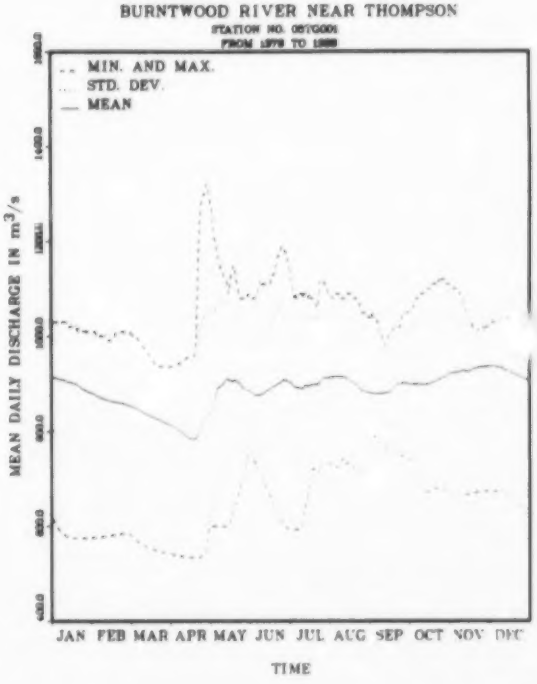
The field study was carried out on May 19, 1988. The weather conditions at the time were ideal as it was warm (18°C), sunny, with negligible wind. Therefore, weather conditions did not affect the quality of the data that was collected.

The Burntwood River is relatively straight within the sampled reach. The channel is trapezoidal in shape and the bed is considered to be stable. Bed-material data indicate the composition of the bed to be a mixture of silt and clay (25%), sand (25%) and gravel (50%) (Penner et al., 1987).

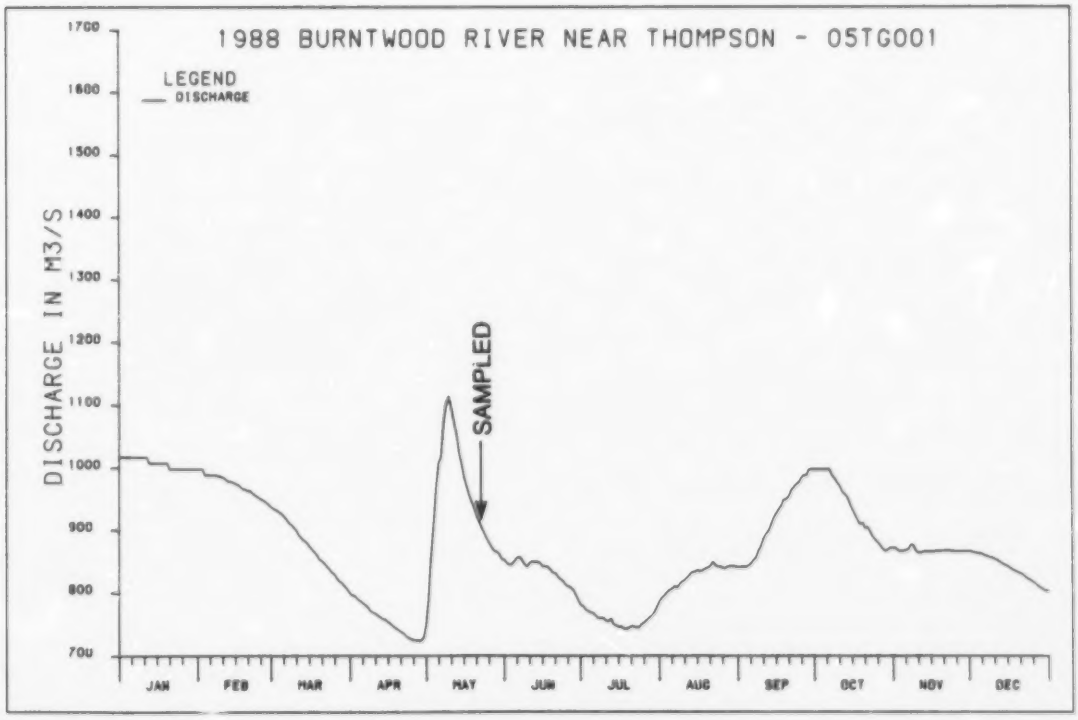
The first full year of regulation on the Burntwood River was 1977. The diversion has resulted in an increase in total annual flows in the order of 7 times that of pre-diversion, while peak discharge has increased by 3 fold. Discharge is maintained within a relatively narrow range as indicated by the flow duration curve (Figure 3a). An average discharge of about 900 m^3/s is maintained year round (Figure 3b). the 1988 hydrograph


BURNTWOOD RIVER NEAR THOMPSON
FULL YEAR
DISCHARGE IN m3/s
MAXIMUM (1380)
MINIMUM (533)
0 10 20 30 40 50 60 70 80 90 100
TIME (%) DATA EQUALLED OR EXCEEDED

3a. Flow Duration Curve


BURNTWOOD RIVER NEAR THOMPSON
MIN. AND MAX.
STD. DEV.
MEAN
MEAN DAILY DISCHARGE IN m3/s
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC
TIME

3b. Hydrograph Summary



3c. 1988 Annual Hydrograph

represents the typical trend (Figure 3c). The sampling itself was carried out on the falling limb of the spring freshet. The stage however remained constant during the time of sampling.

Since regulation, sediment concentrations have been measured by WRB in the 16-36 mg/L range (Environment Canada, 1988). The Thompson cross section is located approximately 2 km downstream of Manassan weir, which results in the water being well mixed. Therefore the sediment tends to be uniformly dispersed as well. No suspended-sediment, particle-size data have been previously collected but, based on the low concentrations, negligible sand is expected to be transported in suspension.

2. ANALYSES AND INTERPRETATION

2.1 Available Data

Appendix B contains all the data and other pertinent information that were collected during this study. Table B.1 (Appendix B) is a compilation of all the concentration data received from the different laboratories. The table also includes information such as sample number used by the various organizations and the time when each sample was collected. Table B.2 contains relevant information on depth-integrating samples such as: intake time, sample volume and the intake ratio. This Appendix also includes the particle-size distribution of the composite sample as determined by WRB using the bottom-withdrawal method.

For simplicity the following code is used to identify the collection method and the individual agencies (Table 1).

Table 1. Data Identification

Agency	Collection Method	Code
1. Water Resources Branch (Environment Canada)	- depth-integrating single vertical	WRB.SV
	- dip sampling	WRB.DIP
2. Freshwater Institute (Fisheries and Oceans)	- dip sampling	FOF.DIP
3. Water Quality Branch (Environment Canada)	- dip sampling	WQF.DIP
4. Manitoba Environment	- dip sampling	WQP.DIP

2.2 Quality Assurance Aspects

The US series of suspended-sediment samplers have certain operational requirements governing their proper usage. These requirements ensure that the principle of isokineticity is followed when sampling (Beverage, 1979). Ideally, this means that the intake velocity should be equal to that of the stream velocity. However, an intake ratio of 1.00 ± 0.15 is considered acceptable for calibration purposes. A quality check (Appendix C) indicates a mean intake ratio of 0.80, slightly below what is considered acceptable.

The sampler that was used in the field study was sent to NWRI for a controlled calibration check in the flume. The results (Appendix C) confirm that indeed there is negative bias. The effect of this bias is an over estimation of sediment concentration. However, as the suspended sediment is primarily silt and clay, the impact will be negligible (in the order of 1-2%; Appendix C).

The sampling iron does not have any quantitative procedures for evaluating the quality of the sample collected. In fact, the only quality control is to ensure the bottles have not been overfilled and that a sufficiently large sample is collected. This was adhered to during this study.

All of the laboratories correctly identified the distilled water blanks.

2.3 Trends in Depth-Integrating Data

Both sets (A and B) of depth-integrating samples are plotted to enable a visual comparison. The two sets follow the same basic trend, with only relatively small deviations existing between the sets (Figure 4a). One point (31 mg/L) however does appear to be an anomaly. Statistical testing (Appendix D.1) confirms this and therefore this point is excluded when normality tests are applied.

In subsequent analyses nonparametric tests are used to treat all data including the outlier. Tests of equal mean and variance are used to determine if there is a significant difference between these two data sets. These tests (Appendix D.2) indicate that there is no significant difference between set A and B. The data have, therefore, been grouped as one population for a further examination of trends.

It would appear that during the first part of the sampling period (8:57 to 10:52) the concentration decreases by ≃ 4 mg/L then becomes relatively constant over the remaining period (Figure 4b). Regression analysis confirms this observation (Appendix D.3).

The question then arises as to whether this is a natural phenomenon or is it a result of sampling error due to changing operators. Figure 4b shows where the operators changed. The change took place during the declining trend and therefore it would appear that this change is not a direct result of changing operators. Even though the second operator's

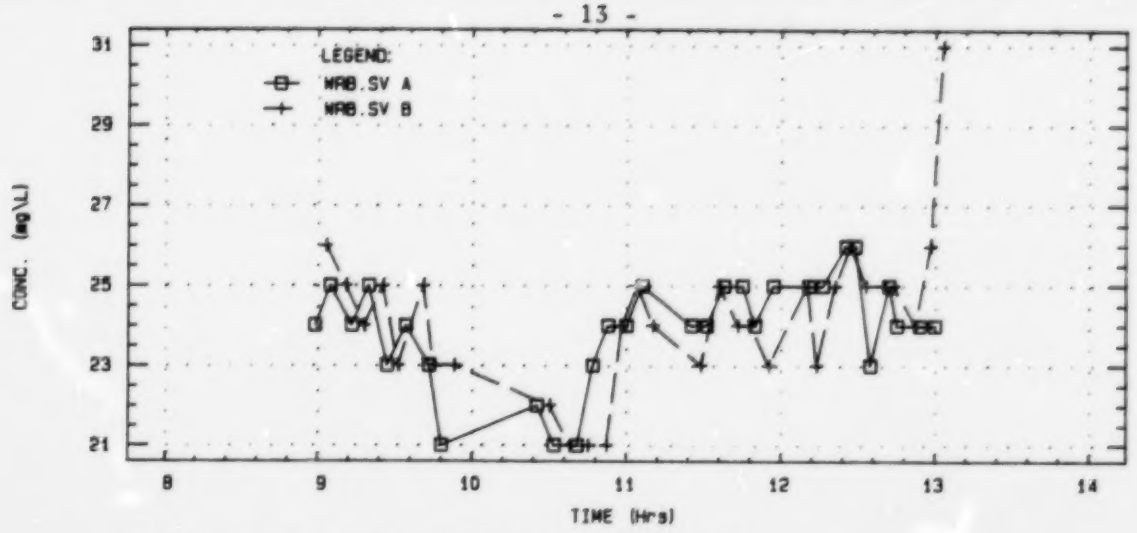


FIGURE 4A: SINGLE VERTICAL SAMPLES (A AND B) VERSUS TIME

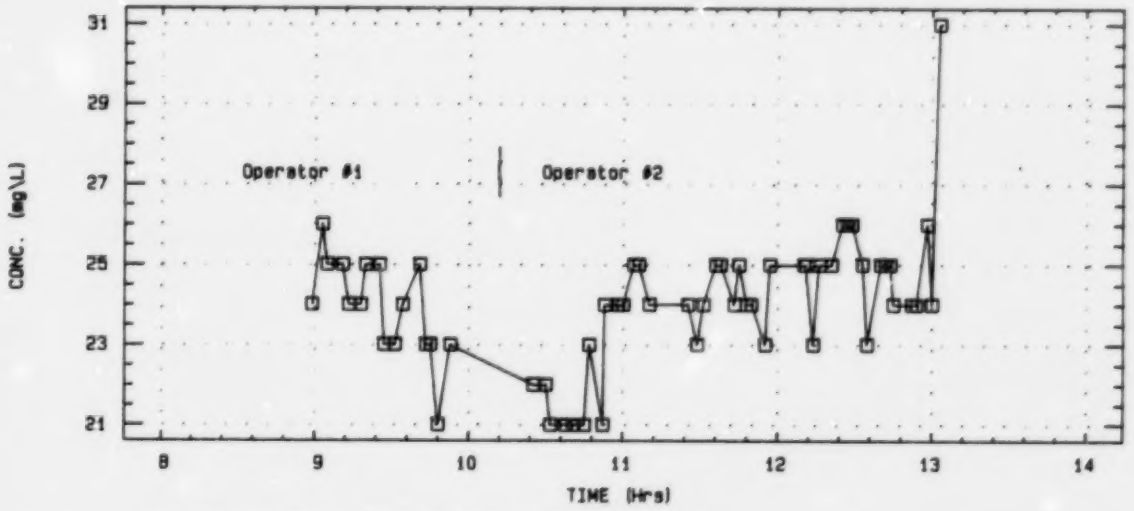


FIGURE 4B: COMBINED (A AND B) SINGLE SAMPLES VERSUS TIME

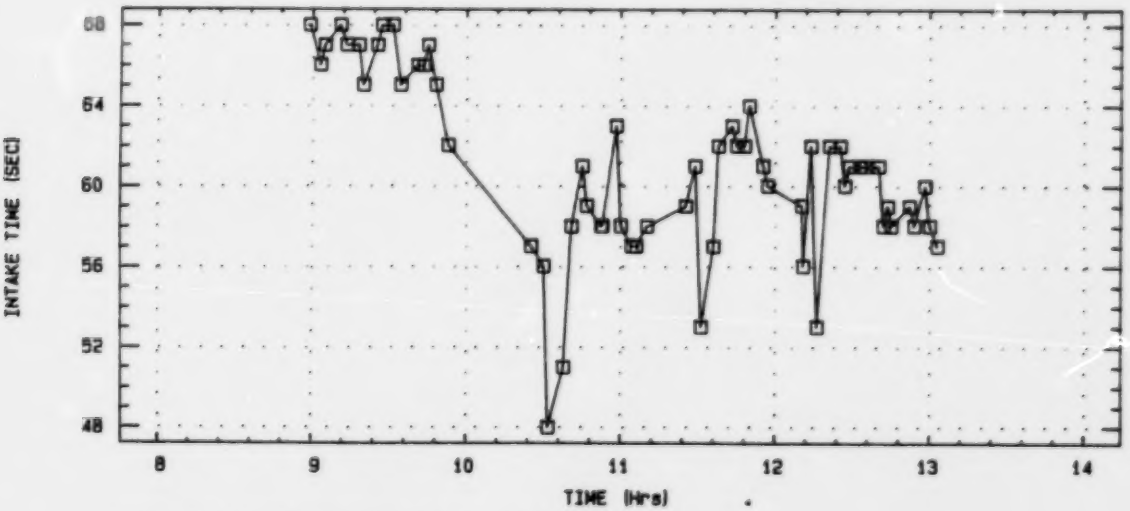


FIGURE 4C: SINGLE VERTICAL INTAKE TIME VERSUS TIME

intake times are lower and more variable (Figure 4c), this change in procedure does not appear to have biased the results (Appendix D.2).

2.4 Sampling Mean, Variance and Precision

No trend in sediment concentration was noted in the dip data (Appendix D.4). The assumption that the data are normally distributed is confirmed using the Kolmogorov-Smirnov goodness of fit test (Appendix D.5) at the 95% confidence interval for all the dip data sets, except WQF.DIP. This set of data is negatively skewed which will require the use of nonparametric tests for evaluating the population.

Each dip data set was also checked for outliers (Appendix D.6). One point in the FOF.DIP set was determined to be an outlier. It is the fifth sample in the set, which only has a concentration of 11 mg/L (Figure 5). Therefore for further statistical analysis this outlier has been excluded or nonparametric tests have been used.

Figure 6a shows the 95% confidence limits of the mean for each data set. Both A and B samples have been grouped for the single vertical analysis, as they are considered to be from the same population. Table 2 shows that in most of the sets the mean can be estimated within $\pm$ 1 mg/L. There are distinguishable differences between the means obtained from each population. The means range from a high of 24 mg/L for the single vertical to a low of 15 mg/L for WQP.DIP. The significance of this will be discussed later in this report.

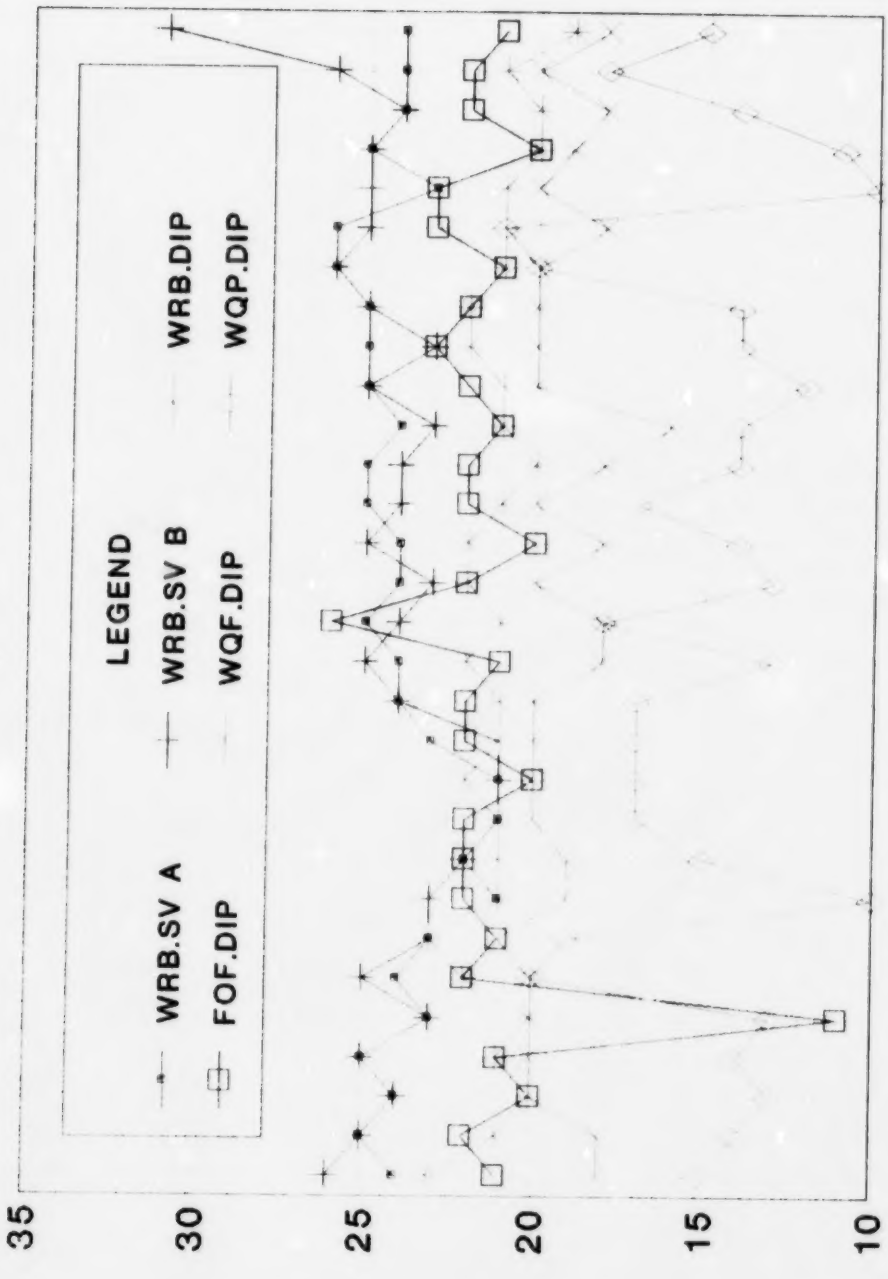


Figure 5. Interagency Sampling Results Comparison

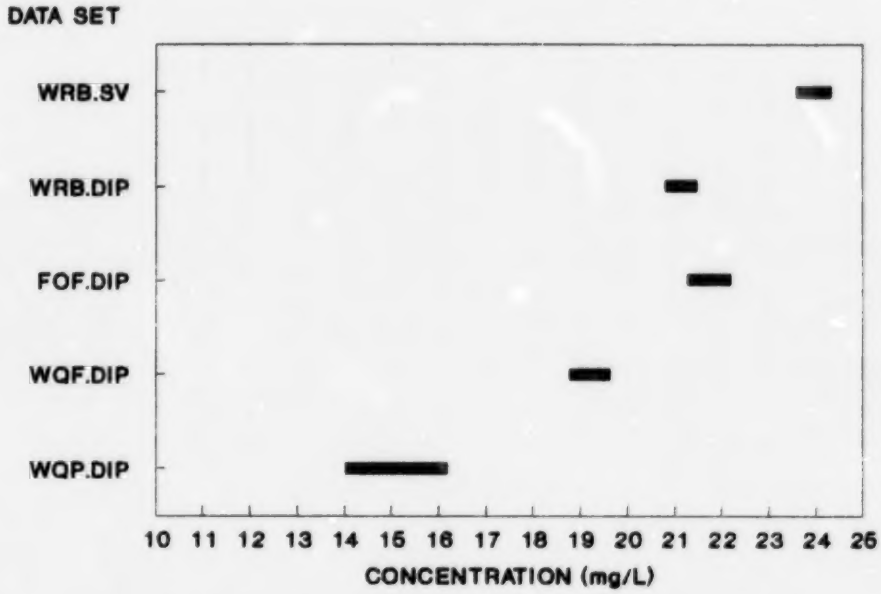


Figure 6a. Mean Sediment Concentration Limits (95% Confidence Level) for Different Data Sets

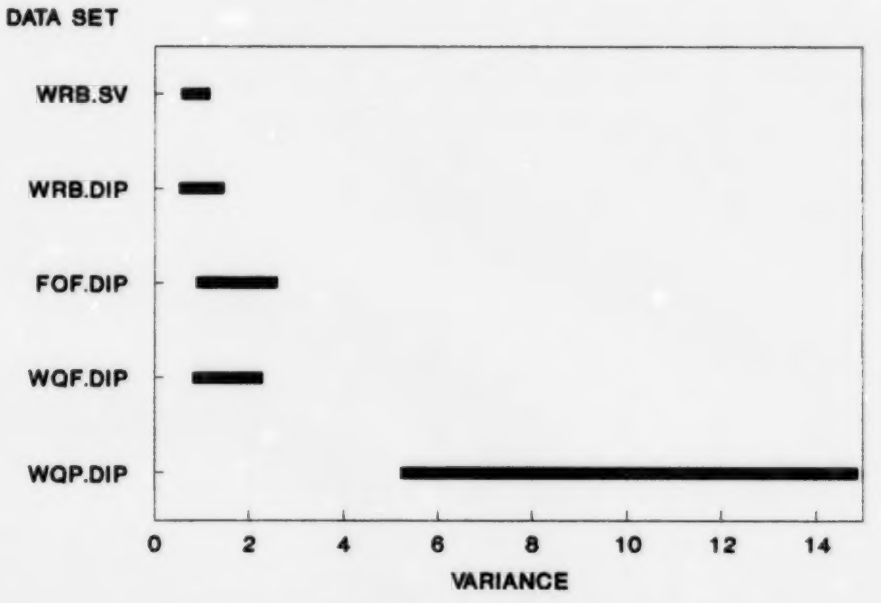


Figure 6b. Variance Limits (95% Confidence Level) For Different Data Sets

Table 2. Mean Concentration Estimates at 95% Confidence Level

Data Set	Mean (mg/L)	Lower Limit (mg/L)	Upper Limit (mg/L)
WRB.SV	23.9	23.6	24.3
WRB.DIP	21.1	20.8	21.5
FOF.DIP	21.7	21.3	22.2
WQF.DIP	19.2	18.8	19.6
WQP.DIP	15.1	14.0	16.2

WQP.DIP not only has a lower mean value than the other data sets, it also has considerable more scatter associated with the data set (Figure 6b) as determined in Appendix D.7. In fact at the 95% confidence level the variance is at least five times greater than the other dip sets (Table 3). From this it is apparent that quality assurance in the laboratories need to be further examined.

Table 3. Variance Estimates at 95% Confidence Level

Data Set	Variance	Lower limit	Upper limit
WRB.SV*	0.8	0.6	1.2
WRB.DIP	0.8	0.5	1.5
FOF.DIP	1.4	0.9	2.6
WQF.DIP	1.3	0.8	2.3
WQP.DIP	8.2	5.2	14.9

*NOTE: The variance has been calculated to exclude the effects of the decreasing trend in concentration.

Table 4 shows the sampling repeatability as calculated (Appendix D.8) for each set. The repeatability for the dips are fairly consistent (≈10%) for all sets except WQP.DIP. The effects from the trend are excluded from the single vertical estimate for repeatability.

Table 4. Sampling Repeatability

Data Set	Precision	
	Absolute (mg/L)	Relative (%)
WRB.SV	2	8
WRB.DIP	2	9
FOF.DIP	2	9
WQF.DIP	2	10
WQP.DIP	6	30

2.5 Methodology (Field) Differences

Based on the means, there is a distinct difference between the results obtained from the depth-integrating and the dip samples. It is well known that in streams with sand in suspension that concentration increases with depth and therefore surface sampling provides negatively-biased estimates (Linton et al., 1988). Wash load (silt and clay) dominated streams tend to be well mixed and this bias is considered to be negligible. Recent work (Ongley et al., in press) however shows that the silt component tends to act similarly to sand, with a slight increase in concentration occuring with depth and typically resulting in a 10% bias.

To evaluate methodology differences the mean of the WRB.SV is compared to the mean of the WRB.DIP (Table 5). Any changes are therefore directly related to methodology and not to laboratory procedures. A bias of -12% is comparable to that of other studies (Ongley et al., in press). Since 50% (Appendix B) of the suspended sediment is comprised of silt-sized material a negative bias in this order can be expected.

Table 5. Comparison of Dip to Depth-Integrating Sampling

Data Set	Difference mg/L	%
WRB.DIP	-2.8	-12
FOF.DIP	-2.2	-9
WQF.DIP	-4.7	-20
WQP.DIP	-8.8	-37

2.6 Agency (Laboratory) Differences

A comparison of the dip sampling results provide information on differences that are directly related to laboratory procedures. As noted in Table 5 the FOF and WRB data sets are comparable, while both water quality agencies provide significantly lower mean estimates, especially WQP.

Appendix E provides details on the laboratory procedures which help to explain the reasons for these differences. It should be noted that none of the agencies use a despersant which might alter the particle-size

distribution. The first thing that is examined to explain the differences is the filters. FOF, WQF and WQP all use a Whatman GF/C filter (retention size 1.2 um) and only WRB uses a Whatman 934AH with a retention size of 1.5 um. This would suggest that the WRB dip results (Table 2) should be lower than the others as the filter is not capable of trapping the finer material. Particle-size data shows that ≈ 50% of the suspended material is clay-sized (<4 um). However, the results show both water quality agencies provide considerably lower estimates, while FOF to be equivalent to WRB. This indicates that filter size is probably not the primary cause of these differences.

Sample size (splitting procedures) is a potential area for introducing error. WRB used the full sample (less 100 ml for total dissolved solids) and therefore provides a good reference basis. FOF used 500 mL as their sample size for analysis and their results are close to that of the WRB. WQF used 250 ml and their results are slightly lower 2 mg/L, while WQP used only 100 ml and their results are significantly lower (6 mg/L). It is therefore apparent that the discrepancies observed are the direct result of sample splitting. It also appears that WQP procedures are not as rigorous as WQF (a sample is agitated ≈ 20 times then the sub-sample is extracted) and that is why the estimate is lower (due to particle settling) and so much more variable.

The small subsample used by water quality agencies introduces a bias in the order of 10% (WQF) to 30% (WQP) in a wash load (silt and clay) dominated river. The larger the particle sizes the more accentuated this error will be.

Limited suspended-sediment data collected at Thompson over a 3-year period show that typically NFR (WQP and WQF) data provided ≈25-100% lower estimates of concentration than WRB data (Northwest Hydraulic Consultants Ltd., 1988). This shows that the error is not systematic and therefore cannot be easily corrected. The results from this study indicate that even under relatively ideal conditions NFR estimates will be lower by 20% (WQF) to 40% (WQP).

3. CONCLUSIONS

The major conclusions that can be made from this study relating to original objectives are:

1. Sampling repeatability of the US D-74 was calculated to be ≈8%, while for the sampling iron it was ≈9%. The effects from the decreasing trend in concentration over the sampling period were eliminated in determining sampling repeatability of the US D-74. Dip sampling results did not indicate any trend. This is probably because changes in concentration are a result of turbulence near the bed and would not impact upon surface conditions (11 m above the bed).

2. WRB laboratory analyses showed that dip sampling underestimated the sediment concentration by ≈12% when compared to depth-integrating results. This negative bias is due to the fact that silts and clays are not uniformly mixed and a slight increase in concentration typically persists with depth.

3. Errors were found to be introduced by the water quality agencies through sample splitting. Splitting techniques were determined to have introduced a negative bias in the results in the order of 10% (WQF) to 30% (WQP).

4. The combined effects from field methodology and laboratory procedures for determining NFR resulted in an underestimation of concentration by 20%(WQF) to 40% (WQP) under relatively ideal conditions.

Other conclusions that relate specifically to the samplers are:

1. The US D-74 sampler used in this particular study probably overestimated the true sediment concentration by 1-2% as a result of sampler limitations. This was not considered to be a significant factor and therefore was not taken into account in this comparison.

2. The sampling iron does not sample strictly a dip, but rather a partial depth-integrated sample. The upper portion (2 m) of the water column was probably sampled during this study.

4. RECOMMENDATIONS

1. This study shows that the sediment data collected by the various agencies are statistically different, even though in absolute terms the differences are small. The use of NFR data provides negatively-biased results even in what is considered to be well mixed conditions. It is therefore recommended that the NFA Sediment Ad Hoc Committee review these limitations prior to proceeding with developing a sediment budget for the Churchill River Diversion.

2. It is recommended that if both water quality agencies continue to collect and analyze NFR data that they analyse the full sample, thereby avoiding the problems inherent with splitting samples.

3. A negative bias of 10-20% as a result of dip sampling is probably tolerable for most sediment needs, especially when weighed against the effort and cost involved in collecting a depth-integrating sample in the North. Therefore, it is recommended that dip sampling be included in further sampling design as long as the full sample is used for analysis.

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Appendix A

Original Study Proposal

STUDY PROPOSAL

TITLE: Interagency Field Sampling and Laboratory Comparison Study at Thompson, Manitoba on Burntwood River

PROBLEM: Agencies (Environment Canada, Fisheries and Oceans Canada, Manitoba Environment) collect suspended sediment data along the Churchill-Nelson Diversion Route using various field methods and equipment and analyze these data in their separate laboratories using differing procedures.

In order to utilize these data cooperatively the differences already noted amongst the data sets must be explained.

OBJECTIVES:

Task 1 Determine the extent of lateral variations in concentration (Note: not incorporated into the field study).

Task 2 Determine the correlation between the depth-integrating, suspended-sediment samples collected by Water Resources Branch (WRB) of Environment Canada, and the dip suspended-sediment samples used by the other agencies.

Task 3 Determine the correlation amongst laboratory results obtained from each of the four laboratories.

METHODOLOGY:

Task 1 WRB Winnipeg to send existing data from sediment measurements to Ottawa Sediment Survey Section for analysis. Section to prepare an evaluation.

Task 2 In order to establish correlation between dip and depth-integrating data.

- use same vertical in cross section for all sampling;
- use a US D-74 suspended sampler (within its operational specifications) for depth-integrating sampling;
- use a Water Quality Branch (WQB) dip sampling iron for all dip samples;
- begin field experiment by taking five samples each with the US D-74 and the dip samplers. This effort should be repeated in the middle and at the end of the experiment. The 15 samples collected by each method over the experiment will allow us to determine the 'mean' particle-size characteristics and also to obtain a measure of the correlation between the particle-size data for each sampling method.

- take a minimum of 30 comparative sets of samples as follows:

- take a depth-integrated sample with the US D-74 (this would be the A sample)

- take four dip samples

- take a second depth-integrated sample with the US D-74 (this would be the B sample)

(Note: It is critical that the identification of the samples within and between sets is kept clear)

Task 3 There are several separate tasks here:

a. the 15 US D-74 and 15 dip samples taken for particle size are to sent to WRB Regina lab for particle-size analysis. Each set of samples should be lumped for analysis to ensure sufficient amount of sediment for the analyses.

b. Each A and B sample of each set are to be analysed separately. This will allow us to establish the precision of the US D-74. WRB Regina is to do these analyses for total concentration.

c. The dip samples taken as part of the comparative sets are to be divided into 4 separate groups to go to each of the 4 labs. Best to send for example, dip sample one from each set to WRB Regina, the second to WQB, etc. Each lab can expect to do at least 30 total concentration analyses.

DATA ANALYSIS: With sufficient samples (30) we should be able to determine:

- precision of US D-74
- correlation between US D-74 and dip data
- difference amongst labs

DOCUMENTATION: Detailed notes should be made during field work (R250's) especially concerning methods, equipment and operators.

All lab procedures are to be documented.

RESPONSIBILITIES: WRB and WQB to coordinate field work.

Sediment Section to provide WRB Winnipeg with sampling bottles, etc. as required.

Each agency to arrange for their own lab support.

Sediment Section to provide data analysis support and will prepare first draft of the evaluation report.

Appendix B

Concentration and Particle-Size Data

Table B.1 Concentration Data [mg/L]

TIME	NUMBER	# SEQ.	WRB SV	WRB DIP	FOF DIP	WQF DIP	WQP DIP
08:30	PS- 1		24				
08:35	PS- 2		24				
08:40	PS- 3		24				
08:45	PS- 4		25				
08:50	PS- 5		25				
08:57	2234	1					15
08:59	1A	1	24				
09:00	2593	1			21		
09:01	880618	1				18	
09:02	2209	1		23			
09:03	1B	1	26				
09:05	2A	2	25				
09:06	2636	2					14
09:07	2645	2			22		
09:08	880619	2				18	
09:09	815	2		21			
09:11	2B	2	25				
09:13	3A	3	24				
09:14	7672	3					13
09:15	7288	3			20		
09:16	880620	3				20	
09:17	7462	3		20			
09:18	3B	3	24				
09:20	4A	4	25				
09:21	7544	4					14
09:22	801	4			21		
09:23	880621	4				20	
09:24	2	4		21			
09:25	4B	4	25				
09:27	5A	5	23				
09:27	7077	5					13
09:29	880622	5				20	
09:29	2236	5			11*		
09:30	2589	5		20			
09:31	5B	5	23				
09:34	6A	6	24				
09:36	7729	6					20
09:38	2629	6			22		
09:39	880623	6				20	
09:40	7487	6		22			
09:41	6B	6	25				
09:43	7A	7	23				
09:44	2196	7					19
09:45	7B	7	23				
09:46	2230	7			21		
09:47	880624	7				21	
09:48	521	7		23			
09:48	8A	8	21				
09:50	7446	8					10
09:51	734	8			22		
09:52	880625	8				19	
09:53	8B	8	23				
09:53	2609	8		21			
10:25	9A	9	22				
10:25	2681	9					15
10:27	2805	9			22		
10:28	80626	9				19	
10:29	2649	9		21			
10:30	9B	9	22				

TIME	NUMBER	# SEQ.	WRB SV	WRB DIP	FOF DIP	WQF DIP	WQP DIP
10:32	10A	10	21				
10:33	129	10					17
10:34	880627	10				20	
10:34	475	10			22		
10:35	6239	10		21			
10:38	10B	10	21				
10:39	4759	11					17
10:41	11A	11	21				
10:42	11B	11			20		
10:43	880628	11				20	
10:44	4625	11		22			
10:45	11B	11	21				
10:47	12A	12	23				
10:47	417	12					17
10:48	2111	12			22		
10:49	880629	12				20	
10:50	65	12		21			
10:52	12B	12	21				
10:53	13A	13	24				
10:53	6943	13					17
10:54	654	13			22		
10:55	880630	13				20	
10:56	442	13		21			
10:58	13B	13	24				
11:00	14A	14	24				
11:01	507	14					13
11:02	880631	14				18	
11:02	829	14			21		
11:03	852	14		22			
11:04	14B	14	25				
11:06	15A	15	25				
11:06	2183	15					18
11:07	878	15			26		
11:08	880632	15				18	
11:08	2681	15		21			
11:10	15B	15	24				
11:16	PS- 6		27				
11:18	PS- 7		24				
11:19	PS- 8		24				
11:21	PS- 9		25				
11:23	PS-10		24				
11:25	16A		24				
11:25	2578	16					13
11:26	7137	16			22		
11:27	880633	16				20	
11:27	7079	16		22			
11:29	16B	16	23				
11:31	17A	17	24				
11:32	2637	17					14
11:33	880634	17				18	
11:33	2015	17			20		
11:34	2677	17		22			
11:36	17B	17	25				
11:38	18A	18	25				
11:39	782	18					17
11:40	559	18			22		
11:41	880635	18				20	
11:41	2162	18		21			
11:43	18B	18	24				

* CONSIDERED AN OUTLIER

Table B.1 Concentration Data [mg/L] (continued)

TIME	NUMBER	# SEQ.	WRB SV	WRB DIP	FOF DIP	WQF DIP	WQP DIP
11:45	19A	19	25				
11:46	805	19					14
11:46	2277	19			22		
11:47	880636	19				18	
11:48	19B	19	24				
11:48	2580	19		20			
11:50	20A	20	24				
11:50	2567	20					14
11:52	2640	20			21		
11:53	880637	20				16	
11:53	2593	20		21			
11:55	20B	20	23				
11:57	21A	21	25				
12:06	21A	21					12
12:07	2194	21			22		
12:08	880638	21				20	
12:08	6150	21		21			
12:10	21B	21	25				
12:11	22A	22	25				
12:11	22A	22					14
12:12	7524	22			23		
12:13	880639	22				20	
12:13	842	22		22			
12:14	22B	22	23				
12:16	23A	23	25				
12:18	23A	23					14
12:18	2265	23			22		
12:19	880640	23				20	
12:19	2553	23		22			
12:21	23B	23	25				
12:24	24A	24					20
12:24	13	24			21		
12:25	24A	24	26				
12:25	880641	24				20	
12:26	7577	24		21			
12:27	24B	24	26				
12:28	25A	25					21
12:29	25A	25	26				
12:30	4811	25			23		
12:31	880642	25				18	
12:32	5841	25		21			
12:33	25B	25	25				
12:33	26A	26					10
12:34	6180	26			23		
12:35	26A	26	23				
12:35	880643	26				20	
12:36	7308	26		21			
12:40	26B	26	25				
12:37	27A	27					11
12:39	27B	27			20		
12:41	27D	27		20			
12:41	880644	27				19	
12:42	27A	27	25				
12:44	27B	27	25				
12:45	28A	28	24				
12:46	28A	28					14
12:47	880645	28				18	
12:47	28B	28			22		
12:48	28D	28		20			
12:52	28B	28	24				

TIME	NUMBER	# SEQ.	WRB SV	WRB DIP	FOF DIP	WQF DIP	WQP DIP
12:54	29A	29	24				
12:55	29A	29					18
12:55	29B	29			22		
12:56	29C	29				20	
12:56	29D	29		21			
12:58	29B	29	26				
13:00	30A	30	24				
13:00	30A	30					15
13:00	30B	30			21		
13:01	30C	30				18	
13:01	30D	30		19			
13:03	30B	30	31*				
13:05	PS-11		26				
13:07	PS-12		28				
13:09	PS-13		25				
13:11	PS-14		25				
13:12	PS-15		26				
13:14	31D			1			
13:17	32D			1			
13:18	31C					<1	
13:21	32C					<1	
13:24	31B				<1		
13:27	32B				1		
13:30	31A						<5
13:32	32A						<5

* CONSIDERED OUTLIER

Table B.2 Depth-Integrated Samples

	Sample A					Sample B				
	Time	Concentration (mg//L)	Volume (ml)	Intake Time (s)	Intake ratio	Time	Concentration (mg/L)	Volume (mL)	Intake Time (s)	Intake ratio
1.	8:59	24	344	68	0.74	9:03	26	324	66	0.72
2.	9:05	25	371	67	0.81	9:11	25	325	68	0.70
3.	9:13	24	336	67	0.74	9:18	24	361	67	0.79
4.	9:20	25	353	65	0.80	9:25	25	368	67	0.81
5.	9:27	23	362	68	0.78	9:31	23	388	68	0.84
6.	9:34	24	362	65	0.82	9:41	25	336	66	0.75
7.	9:43	23	350	66	0.78	9:45	23	347	67	0.76
8.	9:48	21	317	65	0.72	9:53	23	330	62	0.78
9.	10:25	22	319	57	0.82	10:30	22	314	56	0.82
10.	10:32	21	293	48	0.90	10:38	21	325	51	0.93
11.	10:41	21	321	58	0.81	10:45	21	350	61	0.84
12.	10:47	23	361	59	0.90	10:52	21	313	58	0.79
13.	10:53	24	305	58	0.77	10:58	24	327	63	0.76
14.	11:00	24	330	58	0.83	11:04	25	385	57	0.99
15.	11:06	25	311	57	0.80	11:10	24	338	58	0.85
16.	11:25	24	352	59	0.87	11:29	23	327	61	0.79
17.	11:31	24	280	53	0.77	11:36	25	284	57	0.73
18.	11:38	25	303	62	0.72	11:40	24	339	63	0.79
19.	11:45	25	320	62	0.76	11:48	24	320	62	0.76
20.	11:50	24	349	64	0.80	11:55	23	315	61	0.76
21.	11:57	25	335	60	0.82	12:10	25	339	59	0.84
22.	12:11	25	289	56	0.76	12:14	23	427	62	1.01
23.	12:16	25	309	53	0.85	12:21	25	314	62	0.74
24.	12:25	26	351	62	0.83	12:27	26	312	60	0.76
25.	12:29	26	341	61	0.82	12:33	25	307	61	0.74
26.	12:35	23	304	61	0.73	12:40	25	311	61	0.75
27.	12:42	25	339	58	0.86	12:44	25	347	59	0.74
28.	12:45	24	301	58	0.76	12:52	24	298	59	0.86
29.	12:54	24	308	58	0.78	12:58	26	341	60	0.83
30.	13:00	24	332	58	0.84	13:03	31	314	57	0.81
	Min	21	280	48	0.72		21	284	51	0.70
	Max	26	371	68	0.90		31	388	68	1.01
	Mean	23.9	328	60	0.80		24.2	334	61	0.80

Fisheries and Environment Canada / Pêches et Environnement Canada
Water Resources / Ressources en eau

SUMMARY OF SUSPENDED SEDIMENT ANALYSIS RESULTS AND CORRECTED CONCENTRATION FOR 19 88
SOMMAIRE DES RÉSULTATS ANALYTIQUES DE SÉDIMENT EN SUSPENSION ET DE CONCENTRATION RECTIFIÉE POUR 19 ____

Stream/Cours d'eau: BURNTWOOD RIVER — Location/Endroit: near Thompson

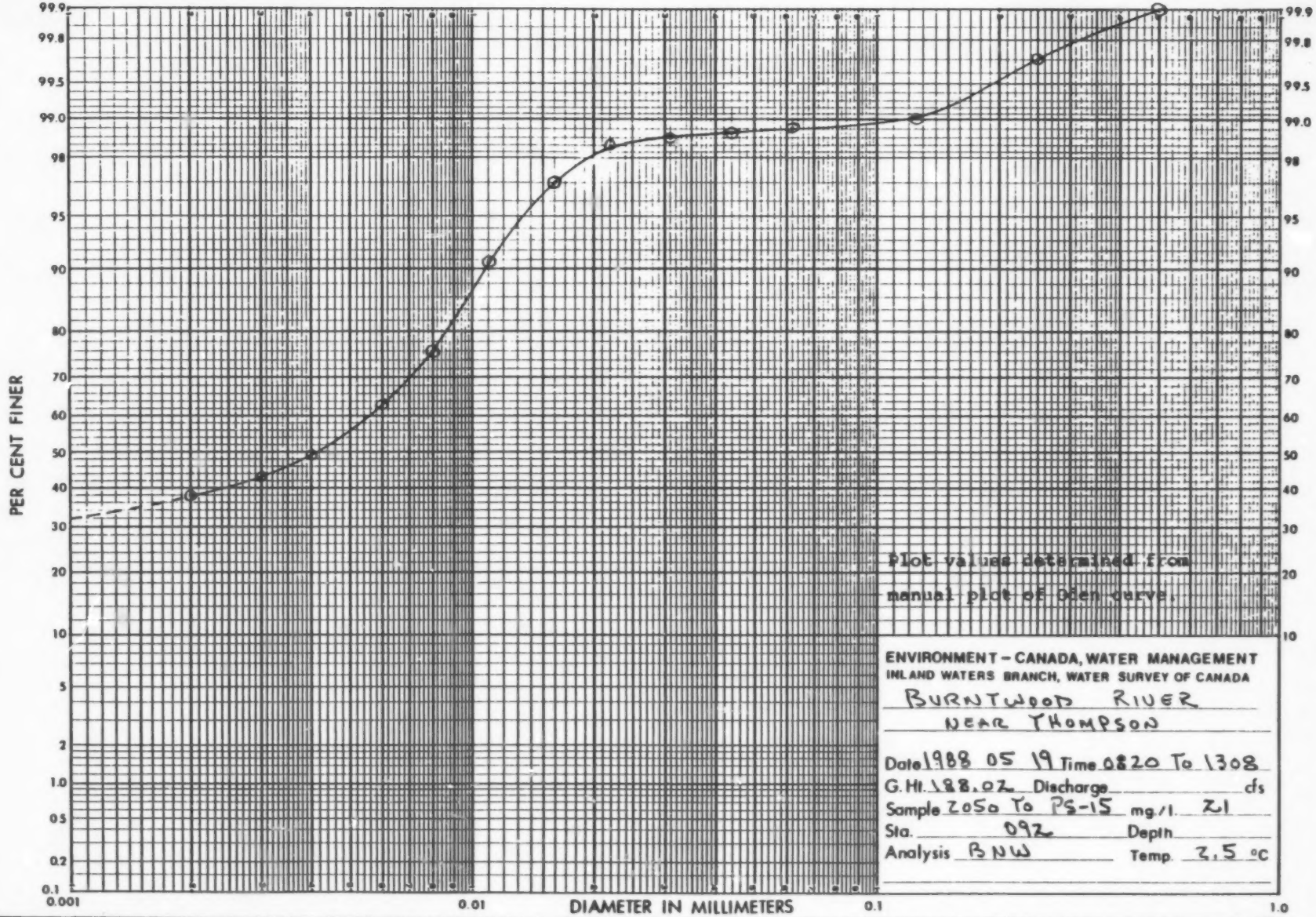
05TG001

Date	Time Heure	Temperature Température °C	Sample vertical Verticale de l'échantillon	River depth Profondeur du cours d'eau	Sample depth Profondeur de l'échantillon	Sample type Type d'échantillon	Sample number N° d'échantillon	Sample volume (cc.) Volume de l'échantillon	Total sample dry weight Échantillon totale poids sec (gr.)	Total concentration (mg/l) Concentration totale	Mean concentration (mg/l) Concentration moyenne	Total sample D_{50} (mm) Échantillon totale	% Sand/Sable .062 to/à 2.0 mm	% Silt/Limon .004 to/à .062 mm	% Clay/Argile < .004 mm	Dissolved Solids (mg/l) Solides dissous	Method of Analysis Méthode d'analyse	Remarks Remarques	(K) Factor Facteur (K)	Corrected concentration Concentration rectifiée
May	0820						2050													
19	to	2.5	092	11.2		DIP	to	14268	0.2991	21		0.004	1.9	48.7	49.4	80	BNW			
	1308						PS-15													
																	BNW	- Bottom Withdrawal Tube		

067-2148 ((11/77)

Computed by/Calculé par: RHY — Date: 1988 07 12 — Checked by/Vérifié par: [signature] — Date: 88/07/12

R253
(8-71)



Plot values determined from manual plot of plan curve.

ENVIRONMENT – CANADA, WATER MANAGEMENT
INLAND WATERS BRANCH, WATER SURVEY OF CANADA

BURNTWOOD RIVER
NEAR THOMPSON

Date 1988 05 19 Time 0820 To 1308
G. Ht. 188.02 Discharge _____ cfs
Sample 2050 To PS-15 mg/l. 21
Sta. 092 Depth _____
Analysis BNW Temp. 3.5 °C

0.001	0.002	0.003	0.004	0.006	0.008	0.011	0.016	0.022	0.031	0.044	0.062	0.125	0.250	0.500	1.000	
32.0E	38.1	42.9	48.8	63.0	76.0	90.8	97.0	98.4	98.6	98.7	98.8	99.0	99.7	99.9		

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Appendix C

Quality Control Check of Depth-Integrating Samples

General Information

1) Site Parameters: depth = 11.2 m
mean stream velocity = 0.861 m/s
mean sampling time = 61 s
mean sampling volume = 331 ml

2) Sampler Specifications (US D-74):

nozzle diameter = 3.18 mm
nozzle area = 7.94 mm^2
bottle volume = 473 mL
maximum depth (foot valve) = 11.6 m
maximum calibrated velocity = 2.0 m/s

Intake Ratio Check:

$$I_R = \frac{\bar{v}}{\bar{t}\ A\ \bar{V}_s} = \frac{331\ mL}{(61\ s)(7.94\ mm^2)(0.861\ m/s)} = 0.80$$

where: I_R = intake ratio
$\bar{v}$ = mean sample volume (mL)
$\bar{t}$ = mean sampling time (s)
A = nozzle area (mm^2)
V_s = mean stream velocity (m/s)

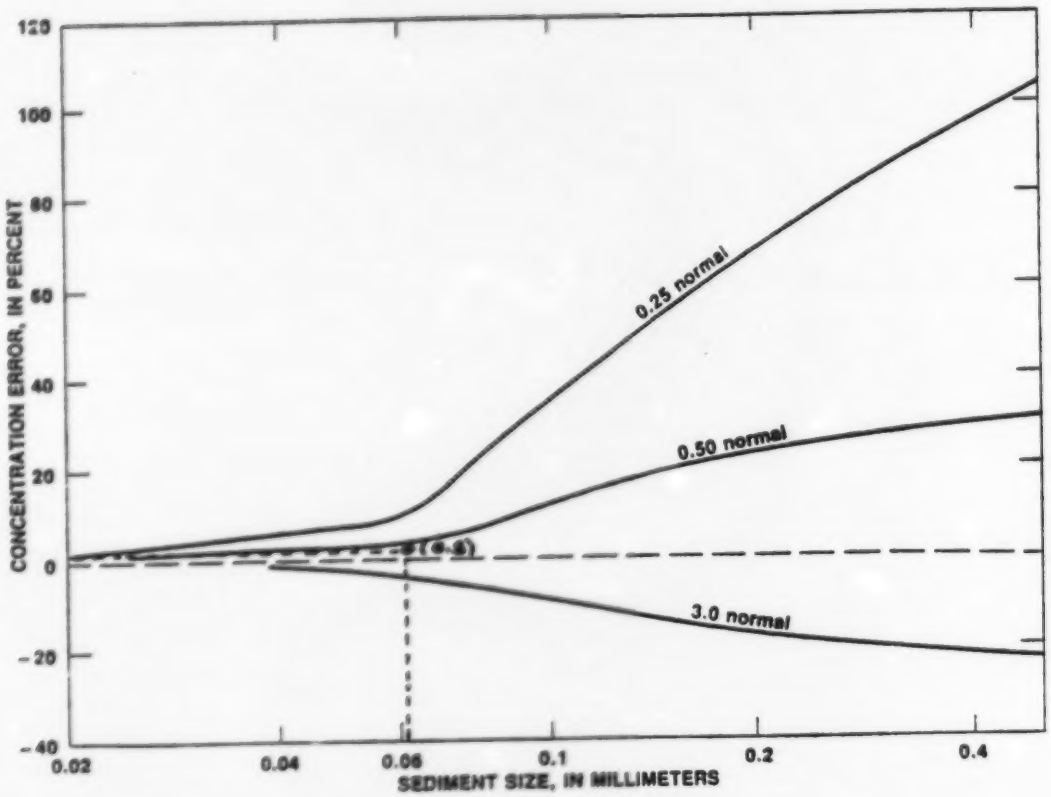
Note: US Series calibrated for intake ratio of 1.00 ± 0.15

Calibration Check

US D-74 Sample (foot valve) - nozzle size 3.18 mm

Carriage Velocity (m/s)	Time (s)	Sample Volume (mL)	Nozzle Velocity (m/s)	Intake Ratio
1.208	32.4	242	0.942	0.78
1.507	27.8	242	1.098	0.73
1.816	25.4	278	1.381	0.76
2.108	19.9	253	1.604	0.76
2.505	16.8	263	1.975	0.79
			average	0.76

Potential Error



(Source: US Inter-Agency Report #5, 1941)

Appendix D

Statistical Tests

APPENDIX D.1

Statistical summaries for data sets.

Data sets:

WRB.SV A:	SV samples noted by a "A",see table B.1;
WRB.SV B:	SV samples noted by a "B";
WRB.SV:	Combined data (A and B).

Results:

				WITHOUT OUTLIER*	
VARIABLE:	SET A	SET B	SV	SET B	SV
SAMPLE SIZE	30	30	60	29	59
AVERAGE	23.9	24.2	24.1	24.0	23.9
MEDIAN	24	24	24	24	24
MODE	24	25	25	25	25
GEOMETRIC MEAN	23.9	24.1	24.0	23.9	23.9
VARIANCE	1.79	3.68	2.71	2.11	1.91
STANDARD DEVIATION	1.34	1.92	1.64	1.45	1.38
STANDARD ERROR	0.24	0.35	0.21	0.27	0.18
MINIMUM	21	21	21	21	21
MAXIMUM	26	31*	31*	26	26
RANGE	5	10	10	5	5
LOWER QUARTILE	23	23	23	23	23
UPPER QUARTILE	25	25	25	25	25
SKEWNESS	-0.89	1.14	0.72	-0.68	-0.76
KURTOSIS	0.47	4.56	4.46	-0.20	-7.65

* All the data sets are considered to be normally distributed (see Appendix D.5). However, sample 30B (31 mg/L) is considered to be an outlier because it deviates by more than three times the standard deviation of a normal distribution. This value is therefore excluded from normal tests and only used in nonparametric tests. The statistical results excluding the outlier are also made available.

APPENDIX D.2

Nonparametric tests for equal mean and variance for WRB.SV data sets.

Type of test: Mann-Whitney test for equal means test,
Squared Ranks test for equal variances test.

Ref: Conover W.J., Practical Nonparametric Statistics, Wiley, 1980, p. 215-223 and p. 239-248.

Assumption: Ho: the means are equal
Ho: the variances are equal

Reject Assumption: H1: the means are not equal at 5% level, i.e. the two-tailed probability of equaling or exceeding Z is lower than 0.05.

H1: the variances are not equal at 5% level, i.e. the two-tailed probability of equaling or exceeding Z is lower than 0.05.

Data compared:

Set A: WRB.SV A
Set B: WRB.SV B

Operator 1: Sampled 1A to 8B

Operator 2: Sampled 9A to 30B

Results:

GROUPS COMPARED	HO: EQUAL MEANS	HO: EQUAL VARIANCES
	TWO-TAILED Z1	TWO-TAILED Z1
SET A AND SET B	0.68: HO ACCEPTED	0.30 : HO ACCEPTED
OPERATOR 1 AND OPERATOR 2	0.65 : HO ACCEPTED	0.86 : HO ACCEPTED

APPENDIX D.3

Regression analysis of WRB.SV results.

First period data set: Sequence number 1A to 12B corresponds to sampling period time 8:57 to 10:52 hrs.

Linear model: Y=a+bX

DEPENDENT VARIABLE:	WRB.SV CONCENTRATION	INDEPENDENT VARIABLE:	TIME

PARAMETER	ESTIMATE	STANDARD ERROR	T VALUE	PROB. LEVEL
INTERCEPT	43.7752	2.93667	14.9064	.0000
SLOPE	-2.09922	0.29794	-7.04579	.0000

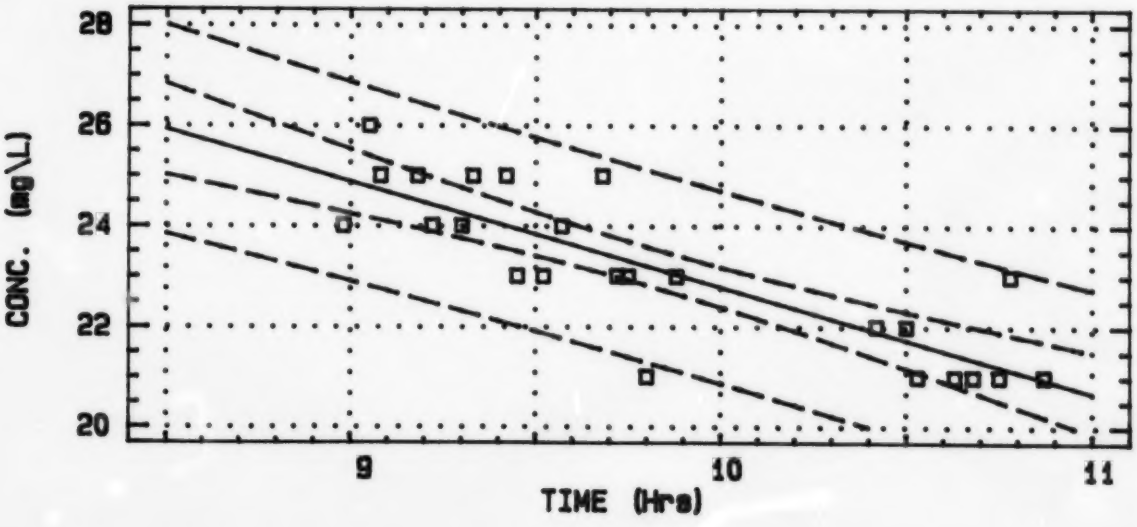
ANALYSIS OF VARIANCE

SOURCE	SUM OF SQUARES	DF	MEAN SQUARE	F-RATIO	PROB. LEVEL
MODEL	40.622571	1	40.622571	49.64311	.00000
ERROR	18.002429	22	0.818292		
TOTAL (CORR.)	58.625000	23			

CORRELATION COEFFICIENT = -0.83242 R-SQUARED = 0.69
VARIANCE OF THE EST. = 0.818292
STND. ERROR OF EST. = 0.904595

The estimated intercept and slope are significantly different from zero as the T values exceed the critical T (2.81) at the 5% level.

First Period (8:57 to 10:52) Versus Time



Regression analysis of WRB.SV results.

Second period data set: Sequence number 13A to 30A corresponds to sampling time 11.0 to 13.0 hrs.

Linear model: Y=a+bX

DEPENDENT VARIABLE:	WRB.SV CONCENTRATION	INDEPENDENT VARIABLE:	TIME

PARAMETER	ESTIMATE	STANDARD ERROR	T VALUE	PROB. LEVEL
INTERCEPT	20.5935	2.69294	7.64723	.0000
SLOPE	0.325891	0.223525	1.45796	.15430

ANALYSIS OF VARIANCE

SOURCE	SUM OF SQUARES	DF	MEAN SQUARE	F-RATIO	PROB. LEVEL
MODEL	1.4973313	1	1.4973313	2.125653	.15430
ERROR	23.245526	33	0.704410		
TOTAL (CORR.)	24.742857	34			

CORRELATION COEFFICIENT = 0.245999 R-SQUARED = 0.06
STND. ERROR OF EST. = 0.839291

For this regression the estimated slope is not significantly different from zero according to the T values is lower than the critical T (2.58) at the 5% level. There is no trend for the second period data set. The following table shows the statistical summary of the second period data set.

SAMPLE STATISTICS:	NUMBER OF OBS	35
	AVERAGE	24.5143
	VARIANCE	0.727731
	STD. DEVIATION	0.853072
	MEDIAN	25
CONFIDENCE INTERVAL FOR MEAN:		95 PERCENT
		24.2212 24.8074 34 D.F.
CONFIDENCE INTERVAL FOR VARIANCE:		95 PERCENT
		0.476136 1.24925 34 D.F.

APPENDIX D.4

Correlation between Dip data and sampling time.

Type of test: Pearson product-moment correlations, " r ".

Ref: Pilon P. J., Condie R., Multiple Linear Regression In Hydrology, Water Resources Branch, Environment Canada, 1983, p. 6 - 7.

Sample Correlations

	WRB	FOF1	WQF	WQP1
TIME	-.3068	.2929	-.1573	-.0033
	(30)	(30)	(30)	(30)
	.0991	.1162	.4063	.9863

Coefficient (sample size) significance level

Note: The first number displayed is the correlation coefficient, followed by the corresponding sample size (in parentheses) and the significance level. The significance levels are based on the student's t distribution with (n-2) degrees of freedom. They represent the probability of non-correlation between the variables. Higher than 5 percent, the non-correlation is considered as significant.

All the data sets present low correlation coefficients and there significance levels indicate a zero correlation between the sample concentration and the sampling time. The data sets can be considered as randomly distributed within a mean value.

APPENDIX D.5

Test to determine if data are normally distributed.

Type of test: Kolmogorov-Smirnov test

Ref: Haan, C.T. Statistical Methods in Hydrology, IOWA State, 1982, p. 176-178, p. 348

Sokal, R.R. and Rohlf F.J., Biometry, W.H. Freemand and Company, 1969.

Assumption: HO, data population is normally distributed.

Reject assumption: H1, data population is not normally distributed at 5% of error.

POPULATION	ABSOLUTE MAXIMUM DEVIATION DMAX	CRITICAL VALUE DCR(0.05)	HO
SINGLE VERTICAL SAMPLING			
WRB.SV SET A	0.238	0.242	ACCEPTED
WRB.SV SET B	0.176	0.242	ACCEPTED
WRB.SV	0.174	0.175	ACCEPTED
DIP SAMPLING			
WRB.DIP	0.240	0.242	ACCEPTED
FOF.DIP	0.234	0.242	ACCEPTED
WQF.DIP	0.335	0.242	REJECTED
WQP.DIP	0.168	0.242	ACCEPTED

APPENDIX D.6

Statistical summary results for dip sampling.

Data analysed:

WRB.DIP
FOF.DIP
WQF.DIP
WQP.DIP

Results:

VARIABLE:	WRB.DIP	FOF.DIP		WQF.DIP	WQP.DIP
			WITHOUT OUTLIER		
SAMPLE SIZE	30	30	29	30	30
AVERAGE	21.1	21.4	21.7	19.2	15.1
MEDIAN	21	22	22	20	14
MODE	21	22	22	20	14
GEOMETRIC MEAN	21.1	21.2	21.7	19.2	14.8
VARIANCE	0.81	5.21	1.42	1.27	8.23
STANDARD DEVIATION	0.90	2.28	1.19	1.13	2.87
STANDARD ERROR	0.16	0.42	0.22	0.21	0.52
MINIMUM	19	11*	20	16	10
MAXIMUM	23	26	26	21	21
RANGE	4	15	6	5	11
LOWER QUARTILE	21	21	21	18	13
UPPER QUARTILE	22	22	22	20	17
SKEWNESS	0.03	-3.14	1.39	-0.89	0.27
KURTOSIS	0.36	15.52	4.96	0.37	-0.44

* Outlier data

All the data sets are considered to be normally distributed (see Appendix D.5), except for the WQF.DIP which is negatively skewed. Therefore, only nonparametric tests are applied.

For the FOF.DIP data, one sample (11 mg/L) is considered to be an outlier because it deviates by more than three times the standard deviation of a normal distribution. This value is therefore excluded from normal tests and only used in nonparametric tests. The statistical results excluding the outlier are also made available.

APPENDIX D.7

Confidence interval of the mean of the population.

Def: the calculated mean is $\bar{x} = \Sigma x_i / n$,

the true mean is between a range of values:

$$\bar{x} \pm \tau(n-1, \alpha/2) \cdot S/\sqrt{n}.$$

REF: Haan C. T.,Statistical Methods in Hydrology,IOWA STATE, 1982.

Results:

POPULATION	N	95% CONFIDENCE INTERVAL OF THE MEAN		
		MEAN	LOWER LIMIT	UPPER LIMIT
WRB.SV	59	23.9492	23.5888	24.3095
WRB.DIP	30	21.1333	20.7974	21.4693
FOF.DIP	29	21.7241	21.2706	22.1777
WQF.DIP	30	19.2000	18.7793	19.6207
WQP.DIP	30	15.1000	14.0285	16.1715

Note: The Mann-Whitney tests,described in Appendix D.2, confirms at the 5% level that:

- the WRB.SV mean, including the outlier, is significantly higher than the other means;
- the FOF.DIP mean,including the outlier, is equal to the WRB.DIP mean and significantly different to the other groups;
- the WQP.DIP mean is significantly different from the other groups.

Confidence interval of the variance of the population.

Def: the calculated variance is $s^2 = \Sigma(xi-\bar{x})^2/(n-1)$,

the confidence interval of the variance is:

$$\left[\frac{(n-1)s^2}{\chi^2_{(n-1)}(1-\alpha/2)} \; , \; \frac{(n-1)s^2}{\chi^2_{(n-1)}(\alpha/2)} \right]$$

REF: Haan C. T.,Statistical Methods in Hydrology,IOWA STATE, 1982.

Results:

POPULATION	N	95% CONFIDENCE INTERVAL OF THE VARIANCE		
		VARIANCE	LOWER LIMIT	UPPER LIMIT
WRB.SV	59	1.91116	1.369580	2.85370
WRB.SV*	59	0.77156	0.550129	1.16086
WRB.DIP	30	0.80920	0.513244	1.46237
FOF.DIP	29	1.42118	0.895016	2.59952
WQF.DIP	30	1.26897	0.804859	2.29326
WQP.DIP	30	8.23103	5.220650	14.8750

* : For the WRB.SV data, the variance has been calculated by eliminating the effect of the negative trend during the first sampling period. The variance has been calculated by using the residuals of the trend for the first sampling period and by using the residuals of the mean for the second sampling period. The degree of freedom (n-1) has been changed to (n-3).

Note: The Mann-Whitney tests,described in Appendix D.2, confirm at the 5 percent level that:

- the WRB.SV variance, including the outlier, is equal to the variances of FOF.DIP, WRB.DIP and WQF.DIP;
- the FOF.DIP variance, including the outlier, is equal to the variance of the other sets, except for the WQP.DIP;
- the WQF.DIP variance is equal to the variance of the other sets, except for the WQP.DIP.

APPENDIX D.8

Precision of the sampling groups.

The precision of an observation with the level accepted is:

$$\tau(n-1,\alpha/2) \cdot s.$$

As the variance of the WRB.SV, WRB.DIP, FOF.DIP and WQF.DIP are not significantly different, the absolute precision has been calculated as a mean s ($\bar{s}$):

$$\bar{s} = \left(\frac{\Sigma[(var(i) \cdot Df(i)]}{\Sigma Df(i)} \right)^{\frac{1}{2}}$$

Results:

POPULATION	Df_i	MEAN	VARIANCE	PRECISION α =5%	
				ABS. mg/L	REL. %
WRB.SV*	56	23.9492	0.77156	1.96882	8.22
WRB.DIP	29	21.1333	0.80920	1.96882	9.32
FOF.DIP	28	21.7241	1.42118	1.96882	9.06
WQF.DIP	29	19.2000	1.26897	1.96882	10.25
WQP.DIP	29	15.1000	8.23103	5.85271	30.48

* : For the WRB.SV data, the variance has been calculated by eliminating the effect of the negative trend during the first sampling period by using the variance of the linear fit estimation instead.

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Appendix E

Laboratory Procedures

TABLE E.1 SUSPENDED SEDIMENT (NFR) LABORATORY ANALYSIS PROCEDURES

Agency	Reference	Filter	Retention Size (um)	Sample Size (ml)	Vacuum Pressure (mm Hg)	Drying Time (hr)	Oven Temperature (°C)
1. Water Resources Branch (WRB)	- Environment Canada, 1987	- AP20 prefilter Whatman 934AH	- 1.5	- full sample (=700-1000 less 100 for total dissolved solids)	- 100-300	3	105
2. Fisheries and Oceans (FOF)	- Stainton et al., 1977	- Whatman GF/C	- 1.2	- subsample of 500	- < 380	1	104
3. Water Quality Branch (WQF)	- Environment Canada, 1974	- Whatman GF/C	- 1.2	- subsample of 250	- not specified	4	105
4. Manitoba and Environment (WQP)	- Internal procedures	- Whatman GF/C	- 1.2	- subsample of 100	- not specified	1	105